

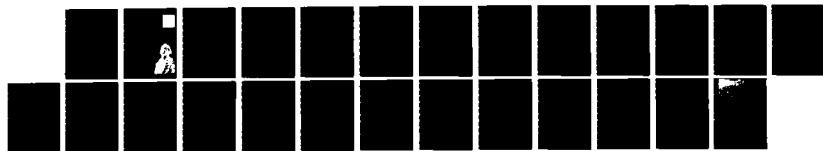
AD-A134 609

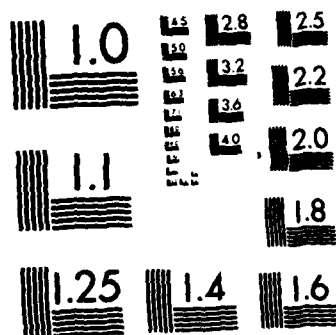
FINAL REPORT ON CONTRACT N00014-75-C-0729 (INVENTORY  
RESEARCH COMPUTATION. (U) GEORGE WASHINGTON UNIV  
WASHINGTON DC INST FOR MANAGEMENT SCIE... W H MARLOW  
30 JUN 83 GWU/IMSE/SERIAL-T-480/83 F/G 15/5

1/1

UNCLASSIFIED

NL





MICROCOPY RESOLUTION TEST CHART  
NATIONAL BUREAU OF STANDARDS-1963-A

AD-A134609

12

FINAL REPORT  
ON  
CONTRACT N00014-75-C-0729

by

W. H. Marlow  
Principal Investigator

THE  
GEORGE  
WASHINGTON  
UNIVERSITY

STUDENTS FACULTY STUDY R  
ESEARCH DEVELOPMENT FUT  
URE CAREER CREATIVITY CC  
MMUNITY LEADERSHIP TECH  
NOLOGY FRONTIER DESIGN  
ENGINEERING APP ENNC  
GEORGE WASHINGTON UNIV



01533

A

DTIC FILE COPY

INSTITUTE FOR MANAGEMENT  
SCIENCE AND ENGINEERING  
SCHOOL OF ENGINEERING  
AND APPLIED SCIENCE

83 11 10 037

FINAL REPORT  
ON  
CONTRACT N00014-75-C-0729

by

W. H. Marlow  
Principal Investigator

Program in Logistics  
GWU/IMSE/Serial T-480/83  
30 June 1983

THE GEORGE WASHINGTON UNIVERSITY  
School of Engineering and Applied Science  
Washington, DC 20052

Institute for Management Science and Engineering

Research Supported  
by  
Contract N00014-75-C-0729  
Project NR 347 020  
Office of Naval Research

This document has been approved for public sale  
and release; its distribution is unlimited.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER GWU/IMSE/Serial T-480/83	2. GOVT ACCESSION NO. AD A134609	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) FINAL REPORT ON CONTRACT N00014-75-C-0729		5. TYPE OF REPORT & PERIOD COVERED ADMINISTRATIVE 1 January 1975 - 30 JUNE 1983
7. AUTHOR(s) W. H. MARLOW		6. PERFORMING ORG. REPORT NUMBER GWU/IMSE/Serial T-480/83
9. PERFORMING ORGANIZATION NAME AND ADDRESS THE GEORGE WASHINGTON UNIVERSITY INSTITUTE FOR MANAGEMENT SCIENCE AND ENGINEERING WASHINGTON, DC 20052		8. CONTRACT OR GRANT NUMBER(s) N00014-75-C-0729
11. CONTROLLING OFFICE NAME AND ADDRESS OFFICE OF NAVAL RESEARCH CODE 411 ARLINGTON, VA 22217		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		12. REPORT DATE 30 June 1983
		13. NUMBER OF PAGES 22
		15. SECURITY CLASS. (of this report)  UNCLASSIFIED
16. DISTRIBUTION STATEMENT (of this Report)  APPROVED FOR PUBLIC SALE AND RELEASE; DISTRIBUTION UNLIMITED.		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number)  LOGISTICS INVENTORY MATHEMATICAL PROGRAMMING NAVAL AIR TRAINING  ACQUISITION RESEARCH READINESS MODELS RELIABILITY		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The period of performance was from 1 January 1975 through 30 June 1983. Work was performed in four areas: inventory research, computational problems in logistics, transportation and economic analyses, and system performance measurements. The present set of references constitutes a complete bibliography of publications and technical reports for the contract.		

DD FORM 1 JAN 73 1473

EDITION OF 1 NOV 65 IS OBSOLETE  
S/N 0102-014-6601

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

THE GEORGE WASHINGTON UNIVERSITY  
School of Engineering and Applied Science  
Washington, DC 20052

Institute for Management Science and Engineering

FINAL REPORT  
ON  
CONTRACT N00014-75-C-0729

by

W. H. Marlow  
Principal Investigator

Abstract  
of  
Program in Logistics  
GWU/IMSE/Serial T-480/83  
30 June 1983

The period of performance was from 1 January 1975 through 30 June 1983. Work was performed in four areas: inventory research, computational problems in logistics, transportation and economic analyses, and system performance measurements. The present set of references constitutes a complete bibliography of publications and technical reports for the contract.

Research Supported  
by  
Contract N00014-75-C-0729  
Project NR 347 020  
Office of Naval Research



✓  
A1

THE GEORGE WASHINGTON UNIVERSITY  
School of Engineering and Applied Science  
Washington, DC 20052

Institute for Management Science and Engineering

FINAL REPORT  
ON  
CONTRACT N00014-75-C-0729

by

W. H. Marlow  
Principal Investigator

Program in Logistics  
GWU/IMSE/Serial T-480/83  
30 June 1983

0. Summary

The period of performance was from 1 January 1975 through 30 June 1983. Work was performed in four areas: inventory research, computational problems in logistics, transportation and economic analyses, and system performance measurements. The present set of references constitutes a complete bibliography of publications and technical reports for the contract. Citations for the latter include the AD numbers by which copies may be ordered from the National Technical Information Service or the Defense Technical Information Center.

1. Inventory research

Research was performed under the following major subject headings: multi-echelon models, inventory modeling utilizing queueing theory, and large-scale logistics modeling.

# References

## Publications

- [1.1] AL-KHAYYAL, F. A. and D. GROSS (1977). On approximating and bounding GI/M/c queues. In M. F. NEUTS (Ed.), North-Holland/TIMS Studies in the Management Sciences, Vol. 7, pp. 223-245. North-Holland.
- [1.2] BARZILY, Z. and M. YADIN (1976). The effect of prior assumptions on the expected cost of M/M/1 queueing systems with unknown arrival rate. Naval Res. Logist. Quart., Vol. 23, pp. 663-671.
- [1.3] \*CRABILL, T. B., D. GROSS and M. J. MAGAZINE (1977). A classified bibliography of research on optimal design and control of queues. Operations Res., Vol. 25, pp. 219-232.
- [1.4] GROSS, D. (1975). Sensitivity of queueing models to the assumption of exponentiality. Naval Res. Logist. Quart., Vol. 22, pp. 271-287.
- [1.5] GROSS, D. (1981). SASPRO II--a spare and server provisioning model. Computers and Operations Research, Vol. 8, pp. 197-207.
- [1.6] GROSS, D. (1982). On the ample service assumption of Palm's theorem in inventory modeling. Management Sci., Vol. 28, pp. 1065-1079.
- [1.7] GROSS, D. and R. J. CRAIG (1974). A comparison of maximum likelihood, exponential smoothing and Bayes forecasting procedures in inventory modeling. Internat. J. Production Res., Vol. 12, pp. 607-622.
- [1.8] GROSS, D. and J. F. INCE (1975). A comparison and evaluation of approximate continuous review inventory models. Internat. J. Production Res., Vol. 13, pp. 9-23.
- [1.9] GROSS, D. and J. F. INCE (1978). Spares provisioning for repairable items: cyclic queues in light traffic. AIIE Transactions, Vol. 10, pp. 307-314.
- [1.10] GROSS, D. and J. F. INCE (1981). The machine repair problem with heterogeneous populations. Operations Res., Vol. 29, pp. 532-549.

\*Sponsored in part by Contract N00014-75-C-0729.



- [1.11] GROSS, D., H. D. KAHN and J. D. MARSH (1977). Queueing models for spares provisioning. Naval Res. Logist. Quart., Vol. 24, pp. 521-536.
- [1.12] GROSS, D. and C. E. PINKUS (1979). Designing a support system for repairable items. Computers and Operations Research, Vol. 6, pp. 59-68.
- [1.13] GROSS, D., C. E. PINKUS and R. M. SOLAND (1981). Designing a multi-product, multi-echelon inventory system. In L. B. SCHWARZ (Ed.), Multi-Level Production/Inventory Control Systems, North-Holland/TIMS Studies in the Management Sciences, Vol. 16, pp. 11-49. North-Holland.
- [1.14] GROSS, D. and D. A. SCHRADY (1976). A survey of inventory theory and practice. In [4.10], W. H. MARLOW (Ed.), pp. 248-295.
- [1.15] HABER, S. E. and R. SITGREAVES (1975). An optimal inventory model for the intermediate echelon when repair is possible. Management Sci., Vol. 21, pp. 638-648.
- [1.16] HARRIS, C. M. (1976a). A note on testing for exponentiality. Naval Res. Logist. Quart., Vol. 23, pp. 169-175.
- [1.17] HARRIS, C. M. (1976b). State-dependent gap acceptance. Naval Res. Logist. Quart., Vol. 23, pp. 653-662.
- [1.18] HARRIS, C. M. (1977). Communication and correction. Naval Res. Logist. Quart., Vol. 24, pp. 695-696.
- [1.19] HARRIS, C. M. and W. G. MARCHAL (1976). A modified Erlang approach to approximating GI/G/1 queues. J. Appl. Prob., Vol. 13, pp. 118-126.
- [1.20] MARCHAL, W. G. (1978). Some simpler bounds on the mean queueing time. Operations Res., Vol. 26, pp. 1083-1088.
- [1.21] PINKUS, C. E. (1975). Optimal design of multi-product multi-echelon inventory systems. Decision Sciences, Vol. 6, pp. 492-507.
- [1.22] SOLAND, R. M. (1983). The design of multiactivity multi-facility systems. European Journal of Operational Research, Vol. 12, pp. 95-104.

- [1.23] THIAGARAJAN, T. R. and C. M. HARRIS (1979). Statistical tests for exponential services from M/G/1 waiting-time data. Naval Res. Logist. Quart., Vol. 26, pp. 511-520.
- [1.24] ZACKS, S. (1974). On the optimality of the Bayes prediction policy in two-echelon multistation inventory models. Naval Res. Logist. Quart., Vol. 21, pp. 569-574.
- [1.25] ZACKS, S. (1981). Statistical problems in the control of multi-echelon inventory systems. In L. B. SCHWARZ (Ed.), Multi-Level Production/Inventory Control Systems, North Holland/TIMS Studies in the Management Sciences, Vol. 16, pp. 225-251. North-Holland.
- [1.26] ZACKS, S. and J. FENNELL (1974). Bayes adaptive control of two-echelon inventory systems. II: The multistation case. Naval Res. Logist. Quart., Vol. 21, pp. 575-593.

#### Technical Papers

- [1.27] AL-KHAYYAL, F. A. and D. GROSS (1976a). On approximating and bounding GI/M/c queues. Technical Paper Serial T-323. (ADA023975).
- [1.28] AL-KHAYYAL, F. A. and D. GROSS (1976b). On approximating and bounding GI/M/c queues--a summary. Technical Paper Serial T-342. (ADA032106).
- [1.29] ARSHAM, H., A. R. BALANA and D. GROSS (1981). Numerical methods for transient solutions of machine repair problems. Technical Paper Serial T-436. (ADA098807).
- [1.30] BARZILY, Z. (1978). The determination of the distribution of the time in the waiting line and the distribution of the length of a busy period in GI/G/1 queues. Technical Paper Serial T-372. (ADA055738).
- [1.31] BARZILY, Z. and D. GROSS (1979). Transient solutions for repairable item provisioning. Technical Paper Serial T-390. (ADA071406).
- [1.32] BARZILY, Z., D. GROSS and H. D. KAHN (1977). Some practical considerations in the application of finite source queueing models. Technical Paper Serial T-360. (ADA045816).

- [1.33] BARZILY, Z. and M. YADIN (1976). The effect of prior assumptions on the expected cost of M/M/1 queueing systems with unknown arrival rates. Technical Paper Serial T-329. (ADA022120).
- [1.34] \*CRABILL, T. B., D. GROSS and M. J. MAGAZINE (1976). A catalog of research on optimal design and control of queues. Technical Paper Serial T-341. (ADA031215).
- [1.35] GROSS, D. (1978). SASPRO--spare and server provisioning program. Technical Paper Serial T-371. (ADA056013).
- [1.36] GROSS, D. (1980). On the ample service assumption of Palm's theorem in inventory modeling. Technical Paper Serial T-433. (ADA094313).
- [1.37] GROSS, D. and J. F. INCE (1977). Spares provisioning for repairable items: cyclic queues in light traffic. Technical Paper Serial T-346. (ADA040136).
- [1.37] GROSS, D. and J. F. INCE (1978). Spares provisioning for a heterogeneous population. Technical Paper Serial T-376. (ADA058692).
- [1.39] GROSS, D., H. D. KAHN and J. D. MARSH (1975). Queueing models for spares provisioning. Technical Paper Serial T-322. (ADA021261).
- [1.40] GROSS, D., H. D. KAHN and J. D. MARSH (1977). Queueing models for spares inventory and repair capacity. Technical Paper Serial T-344. (ADA037014).
- [1.41] \*GROSS, D. and D. R. MILLER (1982). Multi-echelon repairable item provisioning in a time-varying environment using the randomization technique. Technical Paper Serial T-468. (ADA129334).
- [1.42] GROSS, D., D. R. MILLER and R. M. SOLAND (1981). A closed queueing network model for multi-echelon repairable item provisioning. Technical Paper Serial T-446. (ADA108401).
- [1.43] GROSS, D. and C. E. PINKUS (1978). Designing a support system for repairable items. Technical Paper Serial T-367. (ADA051515).
- [1.44] GROSS, D., C. E. PINKUS and R. M. SOLAND (1979). Designing a multi-product multi-echelon inventory system. Technical Paper Serial T-392. (ADA073453).

\*Sponsored in part by Contract N00014-75-C-0729.

- [1.45] GROSS, D. and D. A. SCHRADY (1974). Survey of inventory theory and practice. Technical Paper Serial T-303. (ADA787601).
- [1.46] GROSS, D. and M. Y. WONG (1979). SASPRO II--spare and server provisioning program. Technical Paper Serial T-391. (ADA072929).
- [1.47] HABER, S. E. and R. SITGREAVES (1981). Optimal inventory models for retail stock under alternative decision rules regarding supplies. Technical Paper Serial T-452. (ADA110548).
- [1.48] \*MILLER, D. R. (1981). Steady-state algorithmic analysis of M/M/c two-priority queues with heterogeneous rates. Technical Paper Serial T-440. (ADA101318).
- [1.49] RAPPOPORT, H. K. (1980). An optimization technique for a multi-time period spares provisioning problem. Technical Paper Serial T-408. (ADA084035).
- [1.50] SITGREAVES, R. (1975a). Computing the value of the maximum likelihood estimate of the parameter of a Poisson distribution truncated below one. Technical Paper Serial T-310. (ADA015670).
- [1.51] SITGREAVES, R. (1975b). A comparison of properties of three estimators of the parameter of a Poisson distribution truncated below one, when the sample size is small. Technical Paper Serial T-311. (ADA015669).
- [1.52] SMITH, W. and Z. BARZILY (1980). Kalman filter techniques for control of repeated economic surveys. Technical Paper Serial T-428. (ADA094312).
- [1.53] \*SOLAND, R. M. (1981). The design of multiactivity multi-facility systems. Technical Paper Serial T-444. (ADA107670).
- [1.54] ZACKS, S. (1979). Statistical problems in the control of multi-echelon inventory systems. Technical Paper Serial T-404. (ADA071449).

\*Sponsored in part by Contract N00014-75-C-0729.

## 2. Computational problems in logistics

Research was performed on applications of mathematical programming to the modeling of logistics problems in situations where no exact solution methods were known, or there were significant computer input problems for associated functions, or there were requirements for post-optimality analyses. More general major subject headings are: nonlinear programming, sensitivity analysis, multi-level programming, and global optimization.

### References

#### Publications

- [2.1] AL-KHAYYAL, F. A. and J. E. FALK (1983). Jointly constrained biconvex programming. Math. Oper. Res., Vol. 8, pp. 273-286.
- [2.2] ARMACOST, R. L. and A. V. FIACCO (1974). Computational experience in sensitivity analysis for nonlinear programming. Math. Programming, Vol. 6, pp. 301-326.
- [2.3] BARD, J. F. and J. E. FALK (1982a). An explicit solution to the multi-level programming problem. Computers and Operations Research, Vol. 9, pp. 77-100.
- [2.4] BARD, J. F. and J. E. FALK (1982b). A separable programming approach to the linear complementarity program. Computers and Operations Research, Vol. 9, pp. 153-159.
- [2.5] BRACKEN, J., J. E. FALK and J. T. MCGILL (1974). The equivalence of two mathematical programs with optimization problems in the constraints. Operations Res., Vol. 22, pp. 1102-1104.
- [2.6] FALK, J. E. (1977). Minimizing the cost of completing a project subject to a bound on the expected delay time. In M. ROUBENS (Ed.), Advances in Operations Research, North-Holland.
- [2.7] \*FALK, J. E. and A. V. FIACCO (1982). The use of mathematical programming: who let the man out? Computers and Operations Research, Vol. 9, pp. 3-5.

\*Sponsored in part by Contract N00014-75-C-0729.

- [2.8] \*FALK, J. E. and K. R. HOFFMAN (1976). A successive underestimation method for concave minimization problems. Math. Oper. Res., Vol. 1, pp. 251-259.
- [2.9] FALK, J. E. and K. HOFFMAN (1977). A nonconvex max-min problem. Naval Res. Logist. Quart., Vol. 24, pp. 441-450.
- [2.10] FALK, J. E. and M. ROSE (1976). Minimizing the cost of servicing an end product subject to a completion time constraint. Operations Res., Vol. 24, pp. 658-674.
- [2.11] FIACCO, A. V. (1976). Barrier methods for nonlinear programming. In Encyclopedia of Computer Science and Technology, Vol. 3, pp. 52-114. Dekker.
- [2.12] FIACCO, A. V. (1979). Barrier methods for nonlinear programming. In A. G. HOLZMAN (Ed.), Operations Research Support Methodology, pp. 377-440. Dekker.
- [2.13] FIACCO, A. V. and R. L. ARMACOST (1978). Sensitivity analysis for parametric nonlinear programming using penalty methods. In W. W. WHITE (Ed.), Computers and Mathematical Programming, pp. 261-269. National Bureau of Standards Special Publication 502. U.S. Department of Commerce.
- [2.14] FIACCO, A. V. and A. GHAEMI (1982). Sensitivity analysis of a nonlinear structural design problem. Computers and Operations Research, Vol. 9, pp. 29-55.
- [2.15] \*FIACCO, A. V. and A. GHAEMI (1982). Sensitivity analysis of a nonlinear water pollution control model using an upper Hudson River data base. Operations Res., Vol. 30, pp. 1-28.
- [2.16] \*FIACCO, A. V. and K. O. KORTANEK (Eds.) (1980). Extremal Methods and Systems Analysis. An International Symposium on the Occasion of Professor Abraham Charnes' Sixtieth Birthday. Lecture Notes in Economics and Mathematical Systems, Vol. 174, Springer.
- [2.17] MARLOW, W. H. (1978). Mathematics for Operations Research. Wiley-Interscience.

\*Sponsored in part by Contract N00014-75-C-0729.

- [2.18] \*MCCORMICK, G. P. (1981). Finding the global minimizer of a function of one variable using the method of constant signed higher order derivatives. In O. L. MANGASARIAN, R. R. MEYER and S. M. ROBINSON (Eds.), Nonlinear Programming 4, pp. 223-243. Academic.
- [2.19] \*NEVINS, A. J. (1974). A human oriented logic for automatic theorem-proving. J. Assoc. Comput. Mach., Vol. 21, pp. 606-621.

#### Technical Papers

- [2.20] ARMACOST, R. L. (1976). Computational experience with optimal value function and Lagrange multiplier sensitivity in NLP. Technical Paper Serial T-335. (ADA026374).
- [2.21] ARMACOST, R. L. and A. V. FIACCO (1976). Sensitivity analysis for parametric nonlinear programming using penalty methods. Technical Paper Serial T-340. (ADA031195).
- [2.22] BARD, J. F. and J. E. FALK (1979a). An explicit solution to the multi-level programming problem. Technical Paper Serial T-388. (ADA069310).
- [2.23] BARD, J. F. and J. E. FALK (1979b). A separable programming approach to the linear complementarity problem. Technical Paper Serial T-403. (ADA072928).
- [2.24] CHHABRA, K. L. and R. M. SOLAND (1980). Program description and user's guide for ZIPCAP--a zero-one integer program to solve multiactivity multifacility capacity-constrained assignment problems. Technical Paper Serial T-423. (ADA091127).
- [2.25] DE SILVA, A. H. (1975). An annotated bibliography of articles from NRLQ (1960-1973) involving elements of optimization. Technical Paper Serial T-327. (ADA022938).
- [2.26] EMAMI, G. and G. P. MCCORMICK (1978). Use of a stable generalized inverse algorithm to evaluate Newton method strategies. Technical Paper Serial T-384. (ADA062098).
- [2.27] FALK, J. E. (1976). Minimizing the cost of completing a project subject to a bound on the expected delay time. Technical Paper Serial T-336. (ADA027882).

- [2.28] FALK, J. E. (1978). Minimizing a project cost with bounds on the expectation and variance of the delay time. Technical Paper Serial T-381. (ADA058137).
- [2.29] FALK, J. E. and K. HOFFMAN (1974). A nonconvex max-min problem. Technical Paper Serial T-304. (ADA002240).
- [2.30] FALK, J. E. and K. HOFFMAN (1975). A successive underestimation method for concave minimization problems. Technical Paper Serial T-316. (ADA013176).
- [2.31] FALK, J. E. and M. ROSE (1975). Minimizing the cost of servicing a product subject to an expected completion time constraint. Technical Paper Serial T-321. (ADA016028).
- [2.32] \*FIACCO, A. V. (1981). Computable optimal value bounds and solution vector estimates for general parametric NLP programs. Technical Paper Serial T-451. (ADA108299).
- [2.33] FIACCO, A. V. and A. GHAEMI (1979a). Optimal treatment levels of a stream pollution abatement system under three environmental control policies. Part I: Solution and analysis of convex equivalents of Ecker's GP models using SUMT. Technical Paper Serial T-387. (ADA068313).
- [2.34] FIACCO, A. V. and A. GHAEMI (1979b). Optimal treatment levels of a stream pollution abatement system under three environmental control policies. Part II: Preliminary sensitivity analysis of a convex equivalent of the fixed dissolved oxygen requirement policy GP model using SENSUMT. Technical Paper Serial T-405. (ADA074216).
- [2.35] FIACCO, A. V. and A. GHAEMI (1980a). Sensitivity analysis of a nonlinear structural design problem. Technical Paper Serial T-413. (ADA083689).
- [2.36] \*FIACCO, A. V. and A. GHAEMI (1980b). A user's manual for SENSUMT: a penalty function computer program for solution, sensitivity analysis, and optimal value bound calculation in parametric nonlinear programs. Technical Paper Serial T-434. (ADA096693).
- [2.37] FIACCO, A. V. and A. GHAEMI (1981a). Sensitivity and parametric bound analysis of optimal steam turbine exhaust annulus and condenser sizes. Technical Paper Serial T-437. (ADA110551).

\*Sponsored in part by Contract N00014-75-C-0729.



- [2.38] FIACCO, A. V. and A. GHAEMI (1981b). A closed form local solution of a nonlinear structural design problem in terms of the design parameters. Technical Paper Serial T-449. (ADA107669).
- [2.39] \*FIACCO, A. V. and J. KYPARISIS (1982). Convexity and concavity properties of the optimal value function in parametric nonlinear programming. Technical Paper Serial T-471.
- [2.40] HARRISON, R. A. (1982). Aircraft production and development schedules. Technical Paper Serial T-463. (ADA118047).
- [2.41] \*KYPARISIS, J. (1982). Optimal value bounds for posynomial geometric programs. Technical Paper Serial T-464. (ADA117994).
- [2.42] MCCORMICK, G. P. (1975). Optimal design of a corrugated transverse bulkhead; an example of the use of the factorable programming language. Technical Paper Serial T-313. (ADA008179).
- [2.43] MCCORMICK, G. P. (1977). Solving inventory problems using the factorable nonlinear programming language. Technical Paper Serial T-357. (ADA042286).
- [2.44] \*MCCORMICK, G. P. (1979a). Locating an isolated global minimizer of a constrained nonconvex program. Technical Paper Serial T-409. (ADA080180).
- [2.45] \*MCCORMICK, G. P. (1979b). Finding the global minimum of a function of one variable using the method of constant signed higher order derivatives. Technical Paper Serial T-411. (ADA081491).
- [2.46] \*MCCORMICK, G. P. (1980). Convergence theory for unconstrained minimization. Technical Paper Serial T-431. (ADA092254).

### 3. Transportation and economic analyses

Research was performed under the following major subject headings: naval aviation training, production and procurement planning, manpower and personnel manpower management for the U.S. Marine Corps, and resource dynamics research.

\*Sponsored in part by Contract N00014-75-C-0729.

### References

#### Publications

- [3.1] BARZILY, Z. and M. RUBINOVITCH (1979). On platoon formation on two-lane roads. J. Appl. Probability, Vol. 16, pp. 347-361.
- [3.2] BENNETT, J. T. and S. E. HABER (1974). The allocation of recruiters among spatial areas. Naval Res. Logist. Quart., Vol. 21, pp. 649-658.
- [3.3] CLARK, R. (1981a). Readiness as a residual of resource-allocation decisions. Defense Management Journal, Vol. 17, pp. 20-24.
- [3.4] CLARK, R. (1981b). The dynamics of naval resource allocations. IEEE 1981 Winter Simulation Conference Proceedings. The Institute of Electrical and Electronic Engineers, Inc.
- [3.5] CLARK, R. and J. W. ABELLERA (1981). Forces of habit: budgeting for tomorrow's fleets. AEI Foreign Policy and Defense Review, Vol. 3, Nos. 2 and 3, pp. 2-55.
- [3.6] HABER, S. E. (1978). On the racial composition of workers available to an organization. In D. T. BRYANT and R. J. NIEHAUS (Eds.), Management Planning and Organizational Design, pp. 395-408. Plenum.
- [3.7] ZACKS, S. and S. E. HABER (1977). Adaptive forecasting of the size of a work force subject to random withdrawals. Naval Res. Logist. Quart., Vol. 24, pp. 493-506.

#### Technical Papers

- [3.8] ARGERSINGER, J. E. (1978). A comparative history of alternative ship procurement policies. Technical Paper Serial T-380. (ADA061002).
- [3.9] BARZILY, Z. (1978). The average speed of a fast vehicle moving in a stream of slow vehicles. Technical Paper Serial T-379. (ADA058136).
- [3.10] \*BARZILY, Z. and M. RUBINOVITCH (1977). On platoon formation on two-lane roads. Technical Paper Serial T-350. (ADA042736).

\*Sponsored in part by Contract N00014-75-C-0729.

- [3.11] BUCKLEY, N. C. (1976). An overview of studies of the impact of military installations and their closings on nearby communities. Technical Paper Serial T-338. (ADA030163).
- [3.12] CAVES, W. E., D. WIELAND and W. L. WILKINSON (1979). An exercise of the dynamic student flow model. Technical Paper Serial T-398. (ADA073834).
- [3.13] \*CAVES, W. E., D. WIELAND and W. L. WILKINSON (1981a). Functional Description for the Dynamic Student Flow Model. Technical Paper Serial T-439. (ADA101320).
- [3.14] \*CAVES, W. E., D. WIELAND and W. L. WILKINSON (1981b). User's Manual for the DSFM. Technical Paper Serial T-447. (ADA110369).
- [3.15] CAVES, W. E. and W. L. WILKINSON (1977). Dynamic flight student flow model. Technical Paper Serial T-362. (ADA047301).
- [3.16] CHHABRA, K. L. (1981). Solving multiactivity multifacility capacity-constrained 0-1 assignment problems. Technical Paper Serial T-441. (ADA102583).
- [3.17] CLAYCOMBE, R. J. (1980). The supply of young craftsmen to an industry. Technical Paper Serial T-421. (ADA088192).
- [3.18] D'AMALIO, J. M. (1979). An application of the SRS/RG in determining enlisted attrition rates in the USMC: program manual. Technical Paper Serial T-397. (Reissue of Serial TM-60470 dated 23 December 1978.) (ADA068432).
- [3.19] D'AMALIO, J. M. and W. W. SEVON (1978). An application of the SRS/RG in determining enlisted attrition rates in the USMC. Technical Paper Serial T-389. (ADA065539).
- [3.20] D'AMALIO, J. M. and T. C. TEEPLES (1979). Statistical retrieval system and rate generator: program manual. Technical Paper Serial T-396. (Reissue of Serial TM-60423 dated 8 September 1978.) (ADA068692).
- [3.21] HABER, S. E. (1975a). Factors influencing attrition in the Marine Corps. Technical Paper Serial T-306. (ADA008178).
- [3.22] HABER, S. E. (1975b). Factors influencing trainability in the Marine Corps. Technical Paper Serial T-314. (ADA010212).

\*Sponsored in part by Contract N00014-75-C-0729.

- [3.23] HABER, S. E. (1976). On the applicability of applicant flow data in establishing fair employment standards. Technical Paper Serial T-332. (ADA024639).
- [3.24] HABER, S. E. (1977). On the racial composition of workers available to an organization. Technical Paper Serial T-351. (ADA042285).
- [3.25] HABER, S. E. and E. J. LAMAS (1980). Applications of a wage-turnover model to the shipbuilding industry. Technical Paper Serial T-414. (ADA083688).
- [3.26] HABER, S. E. and J. C. MARTIN (1976). An overview of the shipbuilding labor market. Technical Paper Serial T-331. (ADA024638).
- [3.27] LENK, B. R. (1977). Government procurement policy: a survey of strategies and techniques. Technical Paper Serial T-354. (ADA041002).
- [3.28] LENK, B. and H. SOLOMON (1979). Some selected issues in the relationship of profit and investment in defense procurement. Technical Paper Serial T-370. (ADA069309).
- [3.29] MARTIN, J. C. (1978). The labor market of the United States shipbuilding industry. Technical Paper Serial T-383. (ADA059224).
- [3.30] MCNICHOLS, G. R. (1976). On the treatment of uncertainty in parametric costing. Technical Paper Serial T-330. (ADA022153).
- [3.31] MOLL, K. D. and D. P. TIHANSKY (1976). Risk-benefit analysis for industrial and social needs. Technical Paper Serial T-339. (ADA030174).
- [3.32] NAPIER, E. D. (1977). HOWGOZIT: A model for naval aviation training. Technical Paper Serial T-361. (ADA046631).
- [3.33] TEEPLES, T. C. (1979). Statistical retrieval system and rate generator: command/management manual. Technical Paper Serial T-395. (Reissue of Serial TM-60418 dated 3 October 1977.)
- [3.34] TOMLINSON, R. E. (1979). Creating a personnel data base with a time dimension for the Marine Corps. Technical Paper Serial T-394. (Reissue of Serial TM-65211 dated 30 June 1974.) (ADA068312).

- [3.35] ZACKS, S. (1975). Adaptive forecasting of the size of a force subject to random withdrawals. Technical Paper Serial T-315. (ADA013175).
- [3.36] ZACKS, S. (1977). Forecasting the retention of Navy pilots. Technical Paper Serial T-358. (ADA042287).
- [3.37] ZACKS, S. and S. E. HABER (1975). A procedure for forecasting the size of a force subject to random withdrawal. Technical Paper Serial T-312. (ADA013174).

#### 4. System performance measurements

Research was performed under the following major subject headings: failure-rate and inspection-interval prediction, time series analysis of failure data, additional reliability research, naval readiness, and Marine Corps readiness.

#### References

#### Publications

- [4.1] \*BARLOW, R. E., J. B. FUSSELL and N. D. SINGPURWALLA (Eds.) (1975). Reliability and Fault Tree Analysis: Theoretical and Applied Aspects of System Reliability and Safety Assessment. Society for Industrial and Applied Mathematics, Philadelphia, PA.
- [4.2] BARLOW, R. E. and N. D. SINGPURWALLA (1974). Averaging time and maxima for dependent observations. In L. D. KORNREICH (Ed.), Proceedings of the Symposium on Statistical Aspects of Air Quality Data, pp. 6-1 to 6-21. U.S. Environmental Protection Agency, Research Triangle Park, NC.
- [4.3] BARZILY, Z., P. R. CATALOGNE and W. H. MARLOW (1981). Assessing Marine Corps readiness. Defense Management Journal, Vol. 17, No. 1, pp. 25-29.
- [4.4] BARZILY, Z., W. H. MARLOW and S. ZACKS (1979). Survey of approaches to readiness. Naval Res. Logist. Quart., Vol. 26, pp. 21-31.

\*Sponsored in part by Contract N00014-75-C-0729.

- [4.5] BROWN, R. A. and N. D. SINGPURWALLA (1975). Some inequalities for certain functions of order statistics from IFR distributions. J. Amer. Statist. Assoc., Vol. 70, pp. 245-247.
- [4.6] \*FORMAN, E. H. and N. D. SINGPURWALLA (1977). An empirical stopping rule for debugging and testing software. J. Amer. Statist. Assoc., Vol. 72, pp. 750-757.
- [4.7] FORMAN, E. H. and N. D. SINGPURWALLA (1979). Optimal time intervals for testing hypotheses on computer software errors. IEEE Trans. Reliab., Vol. R-28, pp. 250-253.
- [4.8] HAINES, A. L. and N. D. SINGPURWALLA (1974). Some contributions to the stochastic characterization of wear. In F. PROSCHAN and R. J. SERFLING (Eds.), Reliability and Biometry: Statistical Analysis of Lifelength. pp. 47-80. Society for Industrial and Applied Mathematics, Philadelphia, PA,
- [4.9] \*KAHN, H. D. (1977). Least squares analysis of accelerated life tests for the power rule and Arrhenius models. In C. P. TSOKOS and I. N. SHIMI (Eds.), The theory and Applications of Reliability with Emphasis on Bayesian and Nonparametric Methods. Vol. II, pp. 437-456. Academic.
- [4.10] MARLOW, W. H. (Ed.) (1976). Modern Trends in Logistics Research. Massachusetts Institute of Technology Press.
- [4.11] \*MASTRAN, D. V. and N. D. SINGPURWALLA (1976). A method for reliability estimation of logical structures. Engineering Fracture Mechanics, Vol. 8, pp. 229-237.
- [4.12] MASTRAN, D. V. and N. D. SINGPURWALLA (1978). A Bayesian estimation of the reliability of coherent structures. Operations Res., Vol. 26, pp. 663-672.
- [4.13] NARASIMHAM, G. V. L., V. F. CASTELLINO and N. D. SINGPURWALLA (1975). On the predictive performance of the BEA quarterly econometric model and a Box-Jenkins type ARIMA model. In E. GOLDFIELD (Ed.), Business and Economic Statistics Section, Proceedings of the American Statistical Association, pp. 501-504. Washington, DC.
- [4.14] SINGPURWALLA, N. D. (1974). Estimation of the join point in a heteroscedastic regression model arising in accelerated life tests. Communications in Statistics, Vol. 3, pp. 853-863.

\*Sponsored in part by Contract N00014-75-C-0729.

- [4.15] \*SINGPURWALLA, N. D. (1975). Time series analysis and forecasting of failure processes. In [4.1], BARLOW, FUSSELL and SINGPURWALLA (Eds.), pp. 483-507.
- [4.16] \*SINGPURWALLA, N. D. (1978). Time series analysis of failure data. Proceedings Annual Reliability and Maintainability Symposium, pp. 107-112. The Institute of Electrical and Electronic Engineers, Inc.
- [4.17] SINGPURWALLA, N. D. (1978). Estimating reliability growth (or deterioration) using time series analysis. Naval Res. Logist. Quart., Vol. 25, pp. 1-14.
- [4.18] \*SINGPURWALLA, N. D. (1980). Analyzing availability using transfer function models and cross spectral analysis. Naval Res. Logist. Quart., Vol. 27, pp. 1-16.
- [4.19] \*SINGPURWALLA, N. D. and F. A. AL-KHAYYAL (1977). Accelerated life tests using the power law model for the Weibull distribution. In C. P. TSOKOS and I. N. SHIMI (Eds.), The Theory and Applications of Reliability with Emphasis on Bayesian and Nonparametric Methods, Vol. II, pp. 381-399. Academic.
- [4.20] \*SINGPURWALLA, N. D. and W. B. BUCHANAN (1977). Some stochastic characterizations of multivariate survival. In C. P. TSOKOS and I. N. SHIMI (Eds.), The Theory and Applications of Reliability with Emphasis on Bayesian and Nonparametric Methods, Vol. II, pp. 329-348. Academic.
- [4.21] SINGPURWALLA, N. D., V. F. CASTELLINO and D. Y. GOLDSCHEN (1975). Inference from accelerated life tests using Eyring type reparameterizations. Naval Res. Logist. Quart., Vol. 22, pp. 289-296.
- [4.22] THIAGARAJAN, T. R. and C. M. HARRIS (1976). A ratio-type goodness-of-fit test for 2-parameter Weibull distributions. IEEE Trans. Reliab., Vol. R-25, pp. 340-343.
- [4.23] ZACKS, S. (1976). Review of statistical problems and methods in logistics research. In [4.10], W. H. MARLOW (Ed.), pp. 227-247.

\*Sponsored in part by Contract N00014-75-C-0729.

- [4.24] ZACKS, S. and Z. BARZILY (1981). Bayes procedures for detecting a shift in the probability of success in a series of Bernoulli trials. Journal of Statistical Planning and Inference, Vol. 5, pp. 107-119.

Technical Papers

- [4.25] BARZILY, Z. (1980). Analyzing MCCRES data. Technical Paper Serial T-427. (ADA095831).
- [4.26] BARZILY, Z., W. H. MARLOW and S. ZACKS (1977). Survey of approaches to readiness. Technical Paper Serial T-364. (ADA048956).
- [4.27] BARZILY, Z., W. H. MARLOW and S. ZACKS (1978). Readiness evaluations using multivariate data reduction. Technical Paper Serial T-385. (ADA063758).
- [4.28] BARZILY, Z., W. H. MARLOW and S. ZACKS (1979). Using multivariate statistical analysis to obtain readiness evaluations. Technical Paper Serial T-412. (ADA080168).
- [4.29] BARZILY, Z., P. R. CATALOGNE and W. H. MARLOW (1980). Assessing Marine Corps readiness. Technical Paper Serial T-430. (ADA095849).
- [4.30] \*BUCHANAN, W. B. and N. D. SINGPURWALLA (1975). Some stochastic characterizations of multivariate survival. Technical Paper Serial T-319. (ADA015668).
- [4.31] \*FORMAN, E. H. and N. D. SINGPURWALLA (1975). An empirical stopping rule for debugging and testing computer software. Technical Paper Serial T-320. (ADA016027).
- [4.32] FORMAN, E. H. and N. D. SINGPURWALLA (1978). Optimal time intervals for testing hypothesis on computer software errors. Technical Paper Serial T-382. (ADA060788).
- [4.33] KAHN, H. D. (1977). A statistical analysis of some models used in accelerated life tests. Technical Paper Serial T-353. (ADA041001).

\*Sponsored in part by Contract N00014-75-C-0729.



- [4.34] NARASINHAM, G. V. L., V. F. CASTELLINO and N. D. SINGPURWALLA (1974). On the predictive performance of the BEA quarterly econometric model and a Box-Jenkins type ARIMA model. Technical Paper Serial T-305. (ADA002242).
- [4.35] NUSSBAUM, B. and N. D. SINGPURWALLA (1977). The stochastic formulation of a modified cobweb model. Technical Paper Serial T-352. (ADA042737).
- [4.36] NUSSBAUM, B. and N. D. SINGPURWALLA (1977). A reexamination of the adaptive expectations hypothesis when applied to a cobweb model. Technical Paper Serial T-355. (ADA042738).
- [4.37] SINGPURWALLA, N. D. (1974). Time series analysis and forecasting of failure rate processes. Technical Paper Serial T-309. (ADA004203).
- [4.38] \*SINGPURWALLA, N. D. (1978). Analyzing availability and readiness using transfer function models and cross spectral analysis. Technical Paper Serial T-369. (ADA055724).
- [4.39] SINGPURWALLA, N. D. and F. A. AL-KHAYYAL (1975). Inference from accelerated life tests using the inverse power law model. Technical Paper Serial T-318. (ADA013678).
- [4.40] \*SINGPURWALLA, N. D., F. A. AL-KHAYYAL and V. F. CASTELLINO (1975). Estimating reliability growth using time series analysis. Technical Paper Serial T-326. (ADA019304).
- [4.41] \*SINGPURWALLA, N. D. and D. R. MILLER (1977). Failure rate estimation using random smoothing. Technical Paper Serial T-347. (ADA04099).
- [4.42] THIAGARAJAN, T. R. (1974). Some new results in the statistical analysis of stochastic process of the reliability and queueing type. Technical Paper Serial T-308. (ADA003928).
- [4.43] ZACKS, S. and Z. BARZILY (1977). Detecting the shift in the probability of success in a series of Bernoulli trials. Technical Paper Serial T-356. (ADA042739).
- [4.44] ZACKS, S., W. H. MARLOW and Z. BARZILY (1981). Category analysis of the Marine Corps Combat Readiness Evaluation System (MCCRES). Technical Paper Serial T-450. (ADA121731).

\*Sponsored in part by Contract N00014-75-C-0729.

- [4.45] \*ZACKS, S. (1982). Classical and Bayesian approaches to the change-point problem: fixed sample and sequential procedures. Technical Paper Serial T-465. (ADA118048).

\*Sponsored in part by Contract N00014-75-C-0729.

END

FILMED

112-88

DTIC